independent axes of the electronic compass and any one sensor can relay a signal that the device has been closed or convey various other types of information. Alternatively, two or more such signals may be used to relay a signal.

FIG. **11** is a circuit diagram of one embodiment showing components that could be used to assemble a magnetic field sensing device **610** (FIG. **6**). The signal from a two axis sensor **1130** (e.g. Honeywell part HMC1052, available from Honeywell International, Inc., Morristown, N.J., USA) is connected to a low voltage dual op amp **1110** (e.g. National Semiconductor LMV358MM, available from National Semiconductor Corporation, Santa Clara, Calif., USA) and in this embodiment, the output signal is connected to a microcontroller **1102**, which serves the function of the processor **602** of FIG. **6**. The output signal, however, is not limited to being used by only a microcontroller. Other circuit components, such as a comparator, can use or process the output signal.

The two axis sensor **1130** serves as the magnetic field sensing device and includes sensors **1118***a* and **1118***b*, which are orthogonally placed in Wheatstone bridge configurations. When a magnetic field is introduced or increased in the orientation that an axis of the sensor is intended to sense, the Wheatstone bridge creates a shift in output voltage across the output terminals OUTA+ and OUTA− **1128***a* or OUTB+ and OUTB− **1128***b*. The typical output range across these terminals is 2.7-3.6 V. The low voltage dual op amp **1110** amplifies the voltage difference about **200** times using op-amps **1112***a* and **1112***b*.

The microcontroller **1102** uses the output voltages **1122***a* and **1122***b* to digitize the result, process and manipulate the result (such as offset correction) and relay a signal to additional circuit components that generate electronic compass orientation. The microcontroller could also be set with a threshold input voltage to determine if the magnet within the cell phone (or other portable information device) is within close proximity to a sensor, or namely has been closed. For example, if either voltage **1112***a* or **1112***b* was above this threshold, the microcontroller would flag the event that the information processing device has been closed. As mentioned previously, however, this signal response could also be done with a comparator where one input terminal is the reference voltage and the other terminal is the output **1122***a* or **1122***b* from the op amp.

One additional use of the microcontroller is to send a signal to the set/reset strap **1108**. In this embodiment, this is realized by using an output signal from the microcontroller along with additional circuitry **1140** to set and reset the resistive elements of the sensors **1118***a* and **1118***b*. The set/reset realigns the magnetic sensitive material that makes up the resistive elements of the sensors. This is advantageous in the event of a large magnetic field applied to the sensors. In the presence of a large magnetic field the sensors may deviate from their intended behavior and should be restored. In typical compassing applications using the HMC1052 sensor, a set/reset signal is pulsed about once a second. If longer battery lifetime is desired, this pulsing can be done less frequently or only at certain events. One such event would be when the portable information device is turned on or closed.

For further information on magnetic sensor designs, reference may be made to the following patents and/or patent applications, all of which are incorporated by reference herein:

U.S. Pat. No. 6,529,114, Bohlinger et al., "Magnetic Field Sensing Device"

U.S. Pat. No. 6,232,776, Pant et al., "Magnetic Field Sensor for Isotropically Sensing an Incident Magnetic Field in a Sensor Plane"

U.S. Pat. No. 5,952,825, Wan, "Magnetic Field Sensing Device Having Integral Coils for Producing Magnetic Fields"

U.S. Pat. No. 5,820,924, Witcraft et al., "Method of Fabricating a Magnetoresistive Sensor"

U.S. Pat. No. 5,247,278, Pant et al., "Magnetic Field Sensing Device"

U.S. patent application Ser. No. 09/947,733, Witcraft et al., "Method and System for Improving the Efficiency of the Set and Offset Straps on a Magnetic Sensor"

U.S. patent application Ser. No. 10/002,454, Wan et al., "360-Degree Rotary Position Sensor"

In addition, U.S. Pat. No. 5,521,501, to Dettmann et al., titled "Magnetic Field Sensor Constructed From a Remagnetization Line and One Magnetoresistive Resistor or a Plurality of Magnetoresistive Resistors" is also incorporated herein by reference, and may provide additional details on constructing a magneto-resistive sensor.

FIG. **12** is an example graph of the voltage output of one axis of the two axis sensor **1130**. As the magnetic field strength increases, the voltage output increases. Note: 1 gauss equals 1 oersted in air. When using the magnetic field sensing device **610** (FIG. **6**), the electronic compass portion of the device will operate in the linear regime of the graph displayed in FIG. **12**; this corresponds to a limiting range of about −10 to 10 gauss (depending on the type of sensor). The sensor is very sensitive to small changes in magnetic field in this regime (approximately 100 μG). However, when a magnetic field, aligned with the sensor, is large enough to be outside the linear regime of the curve, the sensor is not useful for compassing applications and cannot discriminate between small changes in magnetic field.

Fortunately, when the sensor is saturated (or outside the linear regime), it is still useful. That is, it still conveys information. When the magnet within the portable information device is brought close to a sensor aligned in an orientation that it senses (e.g. the portable information device is closed), the magnetic field acting on the sensor will saturate the sensor. The sensor will then output a constant voltage representative of the non-linear region of the curve. Thus, a saturated sensor will create a constant output, indicative of the sensor being in close proximity to the magnet. The microcontroller **1102** or other circuit components can discriminate the difference in output voltage from the op amps **1112***a* or **1112***b* as the output voltage will be outside the operating range normally seen, or it will be at the constant output value normally seen when the sensors are being used for the electronic compass.

An embodiment of the present invention has been described above. Those skilled in the art will understand, however, that changes and modifications may be made to this embodiment without departing from the true scope and spirit of the present invention, which is defined by the claims.

We claim:

1. A portable information device comprising:

a magnet located at a first portion of the portable information device; an electronic compass located at a second portion of the portable information device, the second portion moveable with respect to the first portion, the electronic compass comprising at least one magnetic sensor responsive to the magnet, the at least one magnetic sensor operating in a first output mode when the first portion is at a first position relative to the second portion, the at least one magnetic sensor operating in a second output mode when the first portion is at a second position relative to the second portion; and